DEPARTMENT OF MECHANICAL ENGINEERING & MECHANICS
COLLEGE OF ENGINEERING & TECHNOLOGY
OLD DOMINION UNIVERSITY
NORFOLK, VIRGINIA 23529

NAVIER-STOKES CALCULATIONS OF SCRAMJET-NOZZLE-AFTERBODY FLOWFIELDS

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By

Oktay Baysal, Principal Investigator

Final Report
For the period ended August 15, 1991

Prepared for
National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia 23665

Under
Research Grant NAG-1-811
James L. Pittman, Technical Monitor
SMD-Aerothermal Loads Branch

Submitted by the
Old Dominion University Research Foundation
P.O. Box 6369
Norfolk, Virginia 23508-0369

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INTRODUCTION

Propulsion-airframe integration for hypersonic airbreathing vehicles is an important feature for the design of a national aero-space plane configuration. The lower afterbody expands the supersonic exhaust gases from the scramjet engine, therefore it becomes a part of the nozzle. This strong coupling between the engine and the airframe necessitates a combined analysis of internal and external flows. The hypersonic freestream and the supersonic exhaust flow mix through a shear layer, where mass, momentum, and energy transfers occur. The interference of the exhaust on the control surfaces of the aircraft can have adverse effects on the stability of the aircraft. Therefore, some method of simulating this type of flow is required to properly design the nozzle and the afterbody region.

A simplified configuration is assumed to model the single-module scramjet nozzle and afterbody. A rectangular duct precedes the internal nozzle, which has a 12° upper surface and a 20° lower surface. The external part of the nozzle is bounded by a 20° ramp and a vertical reflection plate. The external hypersonic flow is initially over a double-corner formed by the reflection plate, the top surface of the nozzle, the exterior of the nozzle sidewall, and a side flat plate. The viscous effects become dominant in all the corner regions. Then both of the flows expand over the 20° ramp. The supersonic jet expands in the axial, the normal, and the spanwise directions as it clears the exit plane. A three dimensional shear layer structure is formed between these coflowing streams which are at different speeds.

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OLD DOMINION UNIVERSITY
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ADVANCES AND APPLICATIONS IN COMPUTATIONAL FLUID DYNAMICS

presented at

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United Engineering Center 345 East 47th Street New York, N.Y. 10017

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